Fruit growth response to temperature is stage-dependent. Under controlled conditions, peach fruit developed typical double-sigmoid growth, with higher temperatures (up to 30 °C) increasing growth rates and shortening the duration of early stages (S1-S2), thereby reducing total development time by more than two weeks compared with cooler regimes. However, the same high temperatures slowed late-stage expansion (S3) and reduced final fruit size, weight, and soluble solids, indicating that while elevated temperatures speed development and advance maturity, they can compromise key quality traits if thermal conditions exceed optimal ranges during critical growth phases.

2.3 Temperature stress impacts on reproductive success

Reproductive processes in peach are particularly vulnerable to temperature extremes around bloom. Controlled-environment studies with ‘Hakuho’ showed that constant temperatures of 25°C-30 °C greatly accelerated bud burst and flowering but reduced flower size, impaired embryo sac development, and markedly lowered fruit set, indicating that temperatures above about 25 °C disrupt normal reproductive organ development and fertilization success. Field and greenhouse comparisons in ‘Granada’ revealed that pre-bloom and bloom high temperatures advanced dormancy break and bloom but delayed female gametophyte development, induced anomalies in male gametophytes, and resulted in low pollen viability, poor synchrony of fertilization, and reduced yield.

More detailed analyses of the progamic phase show contrasting temperature sensitivities of male and female functions. Within a moderate range, increasing temperature accelerates pollen germination and pollen tube growth and increases the number of tubes reaching the style base, but simultaneously causes a sharp decline in stigmatic receptivity, first for supporting tube penetration, then germination, and finally pollen adhesion. Additional work comparing cultivars under subtropical fluctuations found that high temperatures (≥25 °C) during bloom reduced in vitro pollen germination and the proportion of normal pollen grains, with stronger negative impacts on fruit set in ‘Granada’ than in ‘Maciel’, highlighting genotype-specific vulnerability of reproductive success to heat episodes at flowering.

3 Temperature Impacts on Peach Yield Formation Mechanisms

3.1 Growing degree days and yield accumulation relationships

Growing degree-based thermal indices provide a mechanistic link between temperature, developmental timing, and yield formation in peach. In subtropical field conditions, cultivars with higher growing degree day (GDD) requirements during fruit development (“Biuti”) achieved larger fruit size and mass, whereas low-GDD cultivars (“Tropical”) showed smaller fruits, indicating that greater thermal accumulation supports longer growth phases and higher yield potential. Similarly, cultivar comparisons in a sub-temperate Himalayan zone showed that mid- and late-season cultivars requiring 1500-1900 GDD produced higher yields and better quality traits (TSS, sugars) than early cultivars with lower GDD, underscoring that cultivar-specific GDD thresholds structure both yield and quality outcomes.

Process-based and simulation approaches further embed growing degree metrics into yield formation. The PEACH tree growth and yield model uses growing degree hours (GDH) accumulated during the first 30 days after bloom to estimate the length of the fruit growth period; incorporating this GDH-harvest date relationship markedly improved predictions of harvest timing and yield across years and locations compared with earlier degree-day formulations. Empirical analyses of spring temperatures also show that high early GDH accumulation shortens the interval from full bloom to a reference date, increasing instantaneous growth rates but ultimately reducing reference-date fruit size when resource supply cannot keep pace with rapid phenological advancement, demonstrating that thermal time can both promote and constrain yield formation depending on seasonal context.

3.2 Heatwaves and yield reduction mechanisms

Short-term heat stress around harvest exerts distinct and sometimes counterintuitive effects on peach yield formation. A regional analysis for South Korea, using municipal yield data and thermal indicators around the ‘Cheonjungdo Baekdo’ harvest window, found that a higher number of hot days (>30 °C) and elevated minimum temperatures during fruit development significantly increased the probability of low-yield years, implicating